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(54) ANTI-SQUEAL BRAKING DEVICE

(71) We, ISUZU MOTORS LIMITED, of 10—22, 6-Chome, Minam-001, Shinagawa-Ku, Tokyo, Japan, a Japanese Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an anti-squeal braking device for disc brakes of motor vehicles.

Squeal is an unpleasant and objectionable vibratory noises caused by the resonance of, for example, a disc in case of a disc brake due to the self-excited vibrations of brake-pads when the brake is applied. The problem of preventing squeal has been one of the most important technical problems in the art.

Various methods and devices for preventing squeal has been proposed so far, but none of them have ever completely eliminated squeal. An object of this invention is to provide an improved means whereby squeal in the brakes may be entirely eliminated.

The present invention consists in a disc brake comprising a rotatable member having a disc securely attached thereto said disc including an outer peripheral portion extending generally perpendicularly to the axis of rotation of said member, brake actuating means adapted to stop said disc and a substantially annular damping plate formed by one or more parts circumferentially installed in the outer peripheral portion of said disc, said plate being flat and having a depth substantially greater than its thickness, the depth of said plate extending in the same direction as said outer peripheral portion of said disc, the natural frequency of vibration of said damping plate or of the parts forming same being different from that of said disc for preventing reasonance and squeal thereof.

In the accompanying drawings:—

Figure 1 is a perspective view of the part of a disc brake to which is applied a disc according to the present invention;

Figure 2 is a sectional view taken along the line A—A of Figure 1;

Figure 3 is a fragmentary sectional view of another embodiment of the present invention;

Figure 4 is a graph showing the frequency analysis of squeal on the field test and;

Figure 5 is a graph for comparing the levels of oscillations or vibrations of the discs of the present invention and of the prior art.

In Figures 1 and 2, reference numeral 1 designates a disc of the type used in motor vehicles, which is secured to the wheel or other rotatable member (not shown) by conventional means, and reference numerals 2 and 3 are brake-pads fixedly secured to support members 4 and 5 in a caliper 6 (generally, brake actuating means) so as to interpose the peripheral surfaces of the disc 1 between the pads 2 and 3. A slit is provided in the peripheral end face of the disc 1 which has a uniform depth throughout the whole periphery. (The dotted line shown in Figure 1 indicates the depth of the slit).

In the slit is positioned a damping plate 8 of substantially greater depth than its thickness and which is, in this case, divided into two sections or parts which in turn are fixedly secured to the disc 1 by rivets (not shown). Alternately, the damping plate 8 may be press-fitted into the slit. The damping plate 8 has a natural frequency of vibration different from that of the disc, and may be of any material having properties such as mechanical properties, heat-resistivity, and the like which are required for brake material. For example, the damping plate 8 may be made of a metal or non-metal, for example, a steel, a non-ferrous metal, a carbon steel, an alloy steel, a cast-iron, plastic or rubber.

In the construction shown in Figure 3, the disc is divided into two sections 10 and 11 the outer surfaces of which are parallel with each other and the damping plate 8 is interposed between and securely fixed to the sections 10 and 11.

The damping plate 8 may be fixed to the

braked member by a casting method, but care should be taken to ensure that the damping plate 8 is not welded to the braked member. The sizes and configuration of the damping plate 8 are not limited to those shown in the accompanying drawings and may be suitably modified within the scope of the appended claims as required. Therefore, the sizes and configuration of the slits may be accordingly changed.

In this specification, "positioning" or "installing" of the damping plate 8 must be understood to be made not only by mechanical methods such as press-fitting or riveting, but also by casting with care being taken not to weld the damping plate to the braked member as described hereinbefore. Next the operation of the present invention having the construction as described above will be described with reference to Figures 1 and 2 in which the present invention is applied to a disc brake. When a brake is applied, the pads 2 and 3 disposed in the caliper 6 are pressed by means of a piston (not shown) against the surface of the rotating disc 1 so as to apply the retarding force thereto. In this case, the self-excited vibrations of the pads 2 and 3 are developed by the friction so that the disc 1 itself is also vibrated. However, since the damping plate 8, having a natural frequency of vibration different from that of the disc 1, is securely fixed to the disc 1 as described above, the damping plate 8 changes the natural vibrations of the disc 1, thereby damping the amplitudes of the vibration, whereby resonance can be prevented from being developed. Thus, it is clearly understood that the resonance of the disc 1 can be substantially prevented by means of the damping plate regardless of the material of the pads, thereby preventing squeal from being developed and that the damping plate can effect the above described operations and actions as long as the damping plate has a natural frequency of vibration different from that of the disc 1, regardless of the material of the damping plate 8.

The material for the pads may be selected freely and also the selection of the material for the damping plate 8 is relatively free as long as the natural frequency of vibration of the damping plate is different from that of the disc. The damping plate can be applied to any conventional disc brake in a simple manner since the damping plate 8 need only be fixed to the peripheral inner portion of the disc 1.

The advantages of the present invention will be more clearly understood from the experimental results to be described hereinafter. The squeal frequency analysis of a conventional disc brake for motor vehicles was made. The analysis showed that the frequencies in the proximity of 3,000 cps influence squeal to a greatest extent. As shown in Figure 4, the frequencies from 600 to 2,100 cps and higher than 4,000 cps were not generated. It was seen that the natural vibrations of the disc were coincident with the frequency of 3,000 cps. The present invention is based upon the idea that squeal can be prevented if a disc which is not susceptible to resonance with the frequency of 3,000 cps is used. Therefore, a disc in which an annular damping plate (one embodiment of this invention) shown in Figures 1 and 2 is fixedly carried by the inner portion of the disc has been invented. The vibration mode of the disc to which the present invention is applied (hereinafter referred to as "new disc") was measured, and it was seen that the vibration mode in the proximity of the frequency of 3,000 cps was disorientated. Furthermore, the measurement of the natural vibrations of the new disc showed that the amplitudes were extremely low as compared with those in case of the conventional disc and that the quality factor deteriorated as shown in Figure 5. Therefore, the degree of vibration damping is very high. In Figure 5, the dotted curve A shows the level of the conventional disc and the solid curve B, the new disc. The amplification factor at the peaks of p_1, p_2, and p_3 are less. Therefore, it can be understood that despite the self-excited vibrations of the pads, the resonance in the wide range of frequencies between 600 to 5,000 cps may be prevented so that no squeal is developed.

WHAT WE CLAIM IS:—

1. A disc brake comprising a rotatable member having a disc securely attached thereto said disc including an outer peripheral portion extending generally perpendicularly to the axis of rotation of said member, brake actuating means adapted to stop said disc and a substantially annular damping plate formed by one or more parts circumferentially installed in the outer peripheral portion of said disc, said plate being flat and having a depth substantially greater than its thickness, the depth of said plate extending in the same direction as said outer peripheral portion of said disc, the natural frequency of vibration of said damping plate or of the parts forming same being different from that of said disc for preventing reasonance and squeal thereof.

2. A disc brake according to claim 1, wherein said disc is divided into at least two annular sections parallel with each other and said annular damping plate is sandwiched between said plates.

3. A disc brake according to claim 1, wherein said disc has a peripheral edge formed with a slit completely around it, said damping plate being divided into two parts and adapted to fit into said slit.

4. A disc brake as claimed in any of the preceding claims, wherein the installation of said damping plate is effected by riveting, casting or press-fitting.

5. A disc brake substantially as described with reference to Figs. 1 and 2, or Fig. 3 in the accompanying drawing.

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